DECLARATION

I, Young Woo Park, Korean Patent Attorney of 5F, Seil Building, 727-13, Yoksam-dong, Gangnam-gu, Seoul, Korea do hereby solemnly and sincerely declare as follows:

1. That I am well acquainted with the English and Korean languages.
2. That the following is a correct translation into English of the accompanying certified copy of a Korean Patent Application No. 2003-29153.

and I make the solemn declaration conscientiously believing the same to be true.

Seoul, August 5, 2009

Young-Woo Park

Young-Woo PARK

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COMMISSIONER

PATENT APPLICATION

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Title of the Invention: METHOD AND APPARATUS FOR CONVERTING A 4-COLOR, AND ORGANIC ELECTRO-LUMINESCENT DISPLAY DEVICE AND USING THE SAME

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To the COMMISSIONER

[ABSTRACT]

[ABSTRACT]

A method for converting 4-color, capable of improving luminance and color sensitivity of a primary color, an apparatus for performing the same and an organic electro-luminescent display apparatus having the same are disclosed. A gamma-converting part converts each of primary RGB data inputted, a remapping part multiplies each of the gamma-converted RGB data by a scaling factor to remap, and a white extracting part defines a minimum data of the remapped RGB gray-scale data as a white color so as to extract. A data determining part subtracts the white color from the remapped RGB gray-scale data so as to determine a new RGB gray-scale data and a new white data from the white color. A reverse-gamma converting part converts each of the determined RGBW gray-scale data to a compensation RGBW gray-scale data, wherein scaling factor becomes 1 so as to improve brightness in case that each of gray-scale levels of the compensation RGBW gray-scale data is substantially a primary color.

[REPRESENTATIVE FIGURE]

FIG. 3

[INDEX WORD]

4-color driving, 4-color, organic electro-luminescent, expanding, primary color, luminance, scale, OELD

[SPECIFICATION]

[TITLE OF THE INVENTION]

METHOD AND APPARATUS FOR CONVERTING A 4-COLOR, AND ORGANIC ELECTRO-LUMINESCENT DISPLAY DEVICE AND USING THE SAME

[BRIEF EXPLANATION OF THE DRAWINGS]

FIG. 1 is a graph showing a conventional 4-color display.

FIG. 2 is a graph showing a 4-color display according to an exemplary embodiment of the present invention.

FIG. 3 is a schematic view showing an organic electro-luminescent display device according to an exemplary embodiment of the present invention.

FIG. 4 is a schematic view showing an exemplary 4-color converting part shown in the FIG. 3.

FIGS. 5a and 5b are graphs showing an operation of a white extracting part.

FIG. 6 is a schematic view showing another exemplary 4-color converting part shown in the FIG. 3.

FIG. 7 is a graph showing gamma characteristics with respect to gray-scale data.

FIGS. 8a to 8c are schematic views showing arrangements of pixels of an organic electro-luminescent display device for 4-color display according to another exemplary embodiment of the present invention.

FIG. 9 is a cross-sectional view showing an organic electro-luminescent display device according to another exemplary embodiment of the present invention.

FIG. 10 is a cross-sectional view showing an organic electro-luminescent display device according to another exemplary embodiment of the present invention.

FIG. 11 is a cross-sectional view showing an organic electro-luminescent display

device according to another exemplary embodiment of the present invention.

FIG. 12 is a cross-sectional view showing an organic electro-luminescent display device according to another exemplary embodiment of the present invention.

<EXPLANATION ON CHIEF REFERENCE NUMERALS OF DRAWINGS >

10: a 4-color converting part	11, 16: a gamma converting part
12: a remapping part	13, 17: a white extracting part
14, 18: a data determining part	15, 19: a reverse-gamma converting part
20: a data driving part	30: a scan driving part
40: an organic EL panel	125: a gate electrode
130: a source electrode	135: a drain electrode
145, 245, 345, 445: a pixel electrode	150, 250, 350, 450: a partition wall
360, 460: a white organic EL layer	16R, 26R: a red organic EL layer
16G, 26G: a green organic EL layer	16B, 26B: a blue organic EL layer
170, 370: a metal electrode	280, 480: a transparent protecting layer
270, 470: a transparent electrode	

[DETAILED DESCRIPTION OF THE INVENTION]

[PROPOSE OF THE INVENTION]

[THE ART TO WHICH THE INVENTION PERTAINS AND THE PRIOR ART]

The present invention relates to a method and an apparatus for converting 4-color, and an organic electro-luminescent display apparatus using the same, and more particularly to a method for converting 4-color, capable of improving luminance and color sensitivity of a primary color, an apparatus for performing the same and an organic electro-luminescent display apparatus using the same.

Generally, a liquid crystal display (LCD) apparatus improves luminance by

means of a 4-color pixel having white (W) color as well as red (R) color, green (G) color and blue (B) color. A luminance of an achromatic color is increased by means of the 4-color display. The achromatic color includes a white color or a mixed color. However, a luminance of a primary color is decreased and a color sensitivity of the primary color changes.

Hereinafter, for convenience of description, an RG system having two colors such as a red (R) color and a green (G) color will be described.

FIG. 1 is a graph showing a conventional 4-color display.

As shown in FIG. 1, displayable colors of RG system are disposed on a rectangle defined by point O, point R, point G and point RG. The RG system has two color pixels of a red pixel and a green pixel. An RGY system may be defined by means of the RG system. The RGY system has a red pixel, a green pixel and a yellow pixel that is an optical mix of the red pixel and the green pixel. The optical mix increases a luminance of the RG system.

That is, when a maximum luminance of the optical mix of the red pixel and the green pixel is substantially the same as a maximum luminance of the yellow pixel, a maximum luminance of an optical mix of the red pixel, the green pixel and the yellow pixel is two times brighter than a maximum luminance of the optical mix of the red pixel and the green pixel. Therefore, an optical mix of color pixels increases luminance.

However, when a primary color is displayed, a primary color pixel does not increase luminance. For example, when a primary red color is displayed by the red pixel, the red pixel does not increase luminance without the yellow pixel. Therefore, displayable colors of RGY system are disposed on a hexagonal region defined by point R, point R'G, point R'G', point RG' and point G.

First original gray-scale data (I) may be displayed by a first extended compensation gray-scale data (I') that are extended twice, but the second original gray-scale data (II) may be displayed by a second extended compensation gray-scale data (II') that are extended less than twice. The first original gray-scale data (I) are disposed on a rectangle defined by point O, point R'G, point R'G' and point RG'. The second original gray-scale data (II) are disposed on out of the rectangle.

A luminance of a mixed color disposed on the rectangle defined by point O, point R'G, point R'G' and point RG' may be increased twice. However, a luminance of a mixed color disposed on a triangular region defined by point O, point R, point R1 or another triangular region defined by point O, point G, point G1 may be increased less than twice.

Each pixel area of color pixels of RGY system is less than each pixel area of color pixels of RG system, thereby decreasing luminance.

The decrease of luminance is also found in RGB system or in RGBW system. The RGB system has red (R) color, green (G) color and blue (B) color. The RGBW system has red (R) color, green (G) color, blue (B) color and white (W) color. In case of primary color, mixing colors is not possible and each pixel area may be decreased, thereby decreasing luminance.

[TECHNICAL OBJECT OF THE INVENTION]

Accordingly, the present invention is to solve the aforementioned problems of the conventional art, and it is an object of the present invention to provide a method for converting 4-color, capable of improving luminance and color sensitivity of a primary color.

Moreover, it is another object of the present invention to provide an apparatus for performing the same.

Moreover, it is still another object of the present invention to provide an organic electro-luminescent display apparatus having the same.

[CONTRUCTION AND OPERATION OF THE INVENTION]

A method for converting a four-color in accordance with one aspect of the present invention, the method comprises the steps of: (a) performing a gamma conversion with respect to primary RGB (red, green, and blue) gray-scale data to generate gamma-converted RGB data; (b) scaling each of the gamma-converted RGB data and then extracting a white color component from the gamma-converted RGB data; (c) determining four-color RGBW (red, green, blue, and white) data using the gamma-converted RGB data and the white color component; and (d) performing a reverse-gamma conversion with respect to the four-color RGBW data to generate compensated four-color RGBW data, wherein a scaling factor for scaling becomes 1 to prevent a luminance decreasing when the gray-scale level of the compensation RGBW gray-scale data are adjacent to a primary color.

Moreover, an apparatus of converting a four-color in accordance with another one aspect of the present invention, comprises a gamma converting part performing gamma conversion with respect to RGB (red, green, and blue) gray-scale data to obtain gamma-converted RGB data; a remapping part multiplying the gamma-converted RGB data by a scaling factor and remapping the multiplication results to generate remapped RGB data; a white extracting part extracting a white color component from the remapped RGB data provided from the remapping part; a data determining part subtracting the white color component from the remapped RGB data to determine a new RGB gray-scale data and to determine the white color component as a new W gray-scale data; and a reverse-gamma converting part performing reverse-gamma conversion with respect to the determined four-color RGBW (red, green, blue, and white) data to

generate reverse-gamma converted RGBW data, wherein when the gray-scale level of the compensation RGBW gray-scale data are adjacent to a primary color, a scaling factor for scaling becomes 1 to prevent a luminance decreasing.

Moreover, an apparatus for converting a four-color in accordance with still another one aspect of the present invention, comprises a gamma converting part performing gamma conversion with respect to RGB (red, green, and blue) gray-scale data to obtain gamma-converted RGB data; a white extracting part extracting a white color component from the gamma-converted RGB data; a data determining part subtracting the white color component from the remapped RGB data to determine a new RGB gray-scale data and to determine the white color component as a new W gray-scale data; and a reverse-gamma converting part performing reverse-gamma conversion with respect to the four-color RGBW data to generate reverse-gamma converted RGBW data, wherein when the gray-scale level of the compensation RGBW gray-scale data are adjacent to a primary color, a scaling factor for scaling becomes 1 to prevent a luminance decreasing.

Moreover, an organic electro-luminescent display device in accordance with further still another one aspect of the present invention, comprises an organic electro-luminescent display panel comprising an organic electro-luminescent element emitting light corresponding to a current applied thereto and a driving element controlling a current of the organic electro-luminescent element to control emitting light of the organic electro-luminescent element; a scan driving part sequentially outputting scan signals; a data driving part outputting data signals to a data lines of the organic electro-luminescent display panel; and a four-color converting part converting primary RGB gray-scale data provided from an external device into compensated RGB gray-scale data and compensated W gray-scale data, the four-color converting part outputting the

compensated RGB gray-scale data and the compensated W gray-scale data to the data driving part.

According to a method for converting 4-color, an apparatus for performing the same and an organic electro-luminescent display apparatus having the same, each of compensation RGBW gray-scale data may be generated by means of a data driving IC (Integrated Circuit) or fixed scaling factor. The compensation RGBW gray-scale data are extended. The data driving IC is capable of processing bigger data bit than primary RGB gray-scale data bit. Therefore, luminance and color sensitivity of a primary color may be improved when a gray-scale level of the compensation RGBW gray-scale data are substantially a gray-scale of a primary color.

Hereinafter, the preferred embodiments of the present invention will be described in detail with reference to the accompanied drawings.

Conventionally, maximum luminance of each color R, G, B may not be increased in an LCD device, after a luminance of a backlight and a color filter is determined. Maximum luminance of each color R, G, B may be increased in an organic electro-luminescent display (hereinafter, referred to as OELD) by means of controlling data voltage. The OELD is an active light emitting type.

As brightness is increased in the LCD device, an optical efficiency i.e. a transmittance is also increased. However, the luminance shows different tendency from the optical efficiency in the OELD device. For example, when a larger current flows in a pixel electrode by controlling a data voltage, a luminance of the OELD increases but the optical efficiency does not increase. Therefore, in order to reduce power consumption, the optical efficiency must be increased. The OELD such as an active matrix OELD (hereinafter, referred to as AMOELD) includes an organic luminescent stack having a plurality of organic thin-films. The organic thin-films are

disposed between an anode electrode and a cathode electrode. The anode electrode has a transparent electrode such as ITO, and the cathode electrode has a metal of low work function.

In an operation, when a direct current is applied to the anode electrode and the cathode electrode, holes from the anode electrode and electrons from the cathode electrode are injected into the organic luminescent layer, thereby a light is generated by recombination of the holes and the electrons.

Accordingly, when a principle difference between an LCD device and an OELD device is used, luminance decreasing and color sensitivity decreasing of a primary color may be solved, which is generated in a driving of 4-color, particularly, in a driving of 4-color of an OELD device. More particularly, the LCD device is scaled as a hexagonal shape as shown in FIG. 1; however, the OELD device according to the present invention is scaled as an extended in a rectangular shape by a predetermined scaling factor (S) as shown in FIG. 2 to scale.

FIG. 2 is a graph showing a 4-color display according to an exemplary embodiment of the present invention.

As shown in FIG. 2, a white (W) gray-scale data are extracted from a primary red, green and blue (RGB) gray-scale data, and then the W gray-scale data are transformed to compensation RGBW gray-scale data. The primary RGB gray-scale data are from an external device, and the compensation RGBW gray-scale data are 4-color data. Therefore, luminance improves an increase of S times, thereby increasing an optical efficiency.

Particularly, when a color is disposed on a hexagonal region defined by point O, point R, point R'G, point R'G', point RG' and point G, original RGB gray-scale data are converted to an RGBW gray-scale data according to the method of FIG. 1, and a

gray-scale is displayed by the converted RGBW gray-scale data.

However, when a color is disposed on a triangular region defined by point R, point R' and point R'G or another triangular region defined by point G, point RG' and point G', an RGBW gray-scale data converted from an original RGB data exceeds an available gray-scale range according to the method of FIG. 1.

Therefore, an RGBW data are displayable in the triangular regions as well as the hexagonal region by means of a data driving IC. The RGBW gray-scale data are converted by the method of FIG. 1, and the driving IC is capable of processing bigger data bit than primary RGB gray-scale data bit. For example, when the primary RGB gray-scale data are 6 bits, the RGBW gray-scale data may be processed by means of the data driving IC. The data driving IC is capable of processing 7 bit gray-scale data or 8 bit gray-scale data, and the RGBW gray-scale data are more than 6 bits.

Referring to FIG. 2, a first primary gray-scale data (I) may be displayable by means of a first compensation gray-scale data (I'), and a second primary gray-scale data (II) may be displayable by means of a second compensation gray-scale data (II'). The second primary gray-scale data (II) are adjacent to a primary color. That is, the second primary gray-scale data (II) is displayable by means of a gray-scale data corresponding to an extended gray-scale so as to improve luminance of the primary color.

A primary RGB gray-scale data are extended to convert to compensation RGBW gray-scale data by means of a scaling factor being more than 1. Preferably, the scaling factor is 2. A 4-color driving is performed so as to process the compensation RGBW gray-scale data converted by the data driving IC. The data driving IC is capable of processing bigger data bits than primary RGB gray-scale data bits. The 4-color driving may be performed when the scaling factor is 1.

That is, the W gray-scale data are extracted from a primary RGB gray-scale data,

and the primary RGB gray-scale data and the W gray-scale data are subtracted to determine a new RGB gray-scale data and a new W gray-scale data, thereby providing a compensation RGBW gray-scale data that are 4-color data. The primary RGB gray-scale data are from an external device, and the scaling factor is 1. Therefore, an optical efficiency of display is increased so as to reduce power consumption while luminance is maintained by addition of the W gray-scale data. The luminance may be increased by means of controlling data voltage.

FIG. 3 is a schematic view showing an organic electro-luminescent display device according to an exemplary embodiment of the present invention.

Referring to FIG. 3, the organic electro-luminescent display device according to the present invention includes a 4-color converting part 10, a data driving part 20, a scan driving part 30 and an organic EL panel 40.

The 4-color converting part 10 converts an RGB gray-scale data (R, G, and B) to compensation RGBW gray-scale data (R', G', B' and W'), and the 4-color converting part 10 provides the data driving part 20 with the compensation RGBW gray-scale data (R', G', B' and W'). The RGB gray-scale data (R, G, and B) is supplied from an exterior host of a graphic controller (not shown). The RGB gray-scale data (R, G, and B) is supplied from an exterior host or a graphic controller (not shown). The compensation RGBW gray-scale data (R', G', B', and W') has a W gray-scale data so as to improve luminance.

The data driving part 20 receives the compensation RGBW gray-scale data (R', G', B', and W') so as to convert the compensation RGBW gray-scale data (R', G', B', and W') to data signals D1, D2, ..., Dm of analog type. The organic electro-luminescent display penal 40 displays the data signal.

The scan driving part 30 provides the organic electro-luminescent display panel

40 with a plurality of scan signals S1, S2, ..., Sn.

The organic electro-luminescent display panel includes a plurality of data lines EL, a plurality of scan lines GL and a plurality of current supplying lines VDDL arranged in a matrix shape. The data lines DL transmit the data signal D1, D2, ..., Dm, the scan lines GL transmit the scan signal S1, S2, ..., Sn, and the current supplying lines VDDL transmit power supplied from an end thereof.

In addition, the organic electro-luminescent display panel 40 includes a plurality of pixels. And each of the pixels has a switching element QS, an organic electro-luminescent EL element and a driving element QD. A first end and a second end of the switching element QS are connected to the data line DL and the scan line GL, respectively. The switching element QS turns on/off the data signal corresponding to the scan signal through a third end thereof. A first end of the EL element is connected to a polarity terminal and the EL element generates a light corresponding to a current supplied. A first end and a second end of the driving element QD are connected to another end of the EL element and the current supplying line VDDL, respectively. The driving element QD controls a current from the first end to the second end or from the second end to the first end corresponding to the on/off of the data signal through a third end of the switching element QS, thereby controlling illumination of the EL element.

The pixel displays a light such as a red light, a green light, a blue light and a white light. The pixel may be an active light-emitting type or a color filter type. The active light-emitting type generates R light, G light, B light or W light by the EL element, directly. The color filter type generates R light, G light, B light or W light through R filter, G filter, B filter or W filter.

FIG. 4 is a schematic view showing an exemplary 4-color converting part shown

in the FIG. 3.

Referring to FIG. 4, the 4-color converting part 10 according to an exemplary embodiment of the present invention includes a gamma converting part 11, a remapping part 12, a white extracting part 13, a data determining part 14 and a reverse-gamma converting part 15, thereby converting the primary RGB gray-scale data to a 4-color RGBW gray-scale data.

The gamma converting part 11 converts each of the primary RGB data by means of subsequent expression 1, thereby providing the remapping part with each of the gamma-converted RGB data.

[Expression 1]

$R\gamma = aR\gamma$

$G\gamma = aG\gamma$

$B\gamma = aB\gamma$

Here, $R\gamma$, $G\gamma$ and $B\gamma$ are normalized luminance of R color, G color and B color with respect to maximum luminance, respectively. The normalized luminance includes luminance data. The 'a' is $(1/Gmax)\gamma$, and the $R\gamma$, the $G\gamma$ and the $B\gamma$ are gray-scale numbers corresponding to R color, G color and B color, respectively. The Gmax is maximum gray-scale level. For example, when full gray-scale is 64, the Gmax is 63.

The remapping part 12 multiplies each of the gamma converted RGB data ($R\gamma$, $G\gamma$ and $B\gamma$) by means of subsequent expression 2 so as to remap, thereby providing the white extracting part 13 and the data determining part 14 with each of the RGB data ($R\gamma$, $G\gamma$ and $B\gamma$).

[Expression 2]

$R\gamma' = SR\gamma$

$G\gamma' = SG\gamma$

$B\gamma' = SB\gamma$

Here, S is a scaling factor. The scaling factor is a ratio of a maximum white luminance of a mix of R color, G color and B color to a maximum white luminance of a mix of R color, G color, B color and W color. Preferably, when a color filter is used, S is 2.

The white extracting part 13 extracts a W color from each of the remapped RGB data ($R\gamma'$, $G\gamma'$ and $B\gamma'$), and provides the data determining part 14 with the extracted W color.

Particularly, as shown in FIG. 5a, when a minimum datum of the remapped RGB data ($R\gamma'$, $G\gamma'$ and $B\gamma'$) is larger than $aGmax\gamma$, the W color, such as block B of FIG. 5a, becomes the $aGmax\gamma$ and is supplied to the data determining part 14.

Moreover, as shown in FIG. 5b, when a minimum datum of the remapped RGB data ($R\gamma'$, $G\gamma'$ and $B\gamma'$) is smaller than $aGmax\gamma$, the W color, such as block B of FIG. 5b, becomes the minimum datum of the remapped RGB data ($R\gamma'$, $G\gamma'$ and $B\gamma'$) and is supplied to the data determining part 14.

[Expression 3]

$W\gamma' = aGmax\gamma$, if, Min ($R\gamma'$, $G\gamma'$ and $B\gamma'$) $\geq aGmax\gamma$

$W\gamma' = \mathrm{Min}$ ($R\gamma'$, $G\gamma'$ and $B\gamma'$), others

The data determining part 14 determines new RGBW data ($R\gamma^*$, $G\gamma^*$ and $B\gamma^*$) by means of the W color extracted from the white extracting part 13 by using subsequent expression 4, thereby providing the reverse gamma compensation part 15 with the new RGBW data ($R\gamma^*$, $G\gamma^*$ and $B\gamma^*$).

[Expression 4]

$R\gamma^* = R\gamma' - W\gamma'$

$G\gamma^* = G\gamma' - W\gamma'$

$B\gamma^* = B\gamma' - W\gamma'$

$W\gamma^* = W\gamma'$

The reverse gamma compensation part 15 provides the data driving part 20 with each of the RGBW data (R', G', B' and W') by means of subsequent expression 5, after reverse-gamma converting.

[Expression 5]

$R' = (R\gamma^*/a)\ 1/\gamma$

$G' = (G\gamma^*/a)\ 1/\gamma$

$B' = (B\gamma^*/a)\ 1/\gamma$

$W' = (W\gamma^*/a)\ 1/\gamma$

When a color near to a primary color such as exterior region of FIG. 2 is displayed, a datum of the 4-color converted R', G', B' data (R', G', B' and W') is larger than a maximum gray-scale level (Gmax), thereby exceeding the maximum luminance displayable by the gray scaling. However, when the gray scaling is extended, a data driving IC is used to display the colors exceeding the maximum luminance. The data driving IC is capable of processing bigger data bits than primary RGB gray-scale data bits. The data driving part 20 may have a plurality of the data driving IC.

The white extracting part 13 extracts W color by means of comparing a minimum datum of the remapped RGB data with the aGmax γ, so that provides the data determining part 14 with the W color, thereby displaying gray-scale.

However, referring to FIG. 5b, the comparison may be omitted and the W color becomes the minimum datum of the remapped RGB data ($R\gamma'$, $G\gamma'$ and $B\gamma'$) so as to provide the data determining part 14 with the W color, thereby displaying gray-scale.

W color may become the remapped RGB data ($R\gamma'$, $G\gamma'$ and $B\gamma'$) without

determining the aGmax γ. Other data except the minimum datum of the remapped RGB data (Rγ', Gγ' and Bγ') become a difference between W color and the remapped RGB data.

Referring to FIG. 4, the gamma converted RGB gray-scale data are multiplied by a scale factor, 2, so as to extend a gray-scale twice, thereby extracting the W color so as to generate the new RGBW gray-scale data. However, a bit number of the data driving IC must be extended. For example, a data driving IC of 64 gray-scale needs 6 bits, but a data driving IC of extended 64 gray-scale such as 70 gray-scale or 80 gray-scale needs 7 bits.

Hereinafter, a method that generates new RGBW gray-scale data without increasing a bit number of the data driving IC or multiplying another scaling factor will be described.

FIG. 6 is a schematic view showing another exemplary 4-color converting part shown in the FIG. 3.

Referring to FIG. 6, a 4-color converting part 10 includes a gamma converting part 16, a white extracting part 17, a data determining part 18 and a reverse gamma converting part 19, thereby converting a primary RGB gray-scale data to a 4-color RGBW gray-scale data according to another exemplary embodiment of the present invention.

The gamma converting part 16 converts each of the primary RGB data by means of subsequent expression 6, thereby providing the white extracting part 17 and the data determining part 18 with each of the gamma-converted RGB data (Rγ, Gγ and Bγ).

[Expression 6]

$R\gamma = aR\,\gamma$

$G\gamma = aG\,\gamma$

$B\gamma = aB\,\gamma$

Here, the $R\gamma$, the $G\gamma$ and the $B\gamma$ are normalized luminance of R color, G color and B color with respect to a maximum luminance, respectively. The normalized luminance includes luminance data. The a is $(1/Gmax)\,\gamma$. The $R\,\gamma$, the $G\,\gamma$ and the $B\,\gamma$ are gray-scale numbers corresponding to R color, G color and B color, respectively. The Gmax is a maximum gray-scale level. For example, when a full gray-scale is 64, the Gmax is 63. The gray-number is between 0 and 63.

The white extracting part 17 extracts W color by means of each of the gamma converted RGB data ($R\gamma$, $G\gamma$ and $B\gamma$), and the white extracting part 17 provides the data determining part 18 with the extracted W color. For example, referring to FIG. 7, a half luminance of a 64 gray-scale is not 32 gray-scale but 46 gray-scale. A W color is determined by means of subsequent expression 7, and the determined W color is supplied to the data determining part 18.

[Expression 7]

$$W\gamma = a46^{\gamma}, \quad \text{if,} \quad \text{Min}(R\gamma, G\gamma \text{ and } B\gamma) \geq a46^{\gamma}$$

$$W\gamma = \text{Min}(R\gamma, G\gamma \text{ and } B\gamma), \quad \text{others}$$

W color becomes a minimum datum of a gamma converted RGB data ($R\gamma$, $G\gamma$ and $B\gamma$), and the determined W color is supplied to the data determining part 18.

[Expression 8]

$$W\gamma = \text{Min}(R\gamma, G\gamma \text{ and } B\gamma)$$

The determining part 18 determines each of a new RGBW data by means of a W color extracted from the W extracting part 17, and the determined new RGBW data ($R'\gamma$, $G'\gamma$, $B'\gamma$ and $W'\gamma$) is supplied to the reverse gamma compensation part 15.

[Expression 9]

$$R\gamma' = R\gamma - W\gamma$$

$G\gamma' = G\gamma - W\gamma$

$B\gamma' = B\gamma - W\gamma$

$W\gamma' = W\gamma$

The reverse gamma compensation part 19 converts each of the RGBW data (R', G', B' and W') by means of subsequent expression 10 and then provides the data driving part 20 with the reverse converted RGBW data (R', G', B' and W').

[Expression 10]

$R' = (R\gamma^*/a)\ 1/\gamma$

$G' = (G\gamma^*/a)\ 1/\gamma$

$B' = (B\gamma^*/a)\ 1/\gamma$

$W' = (W\gamma^*/a)\ 1/\gamma$

The white extracting part 13 extracts W color by means of comparing a minimum datum of the gamma converted RGB data ($R\gamma$, $G\gamma$ and $B\gamma$) with the $a46^{\gamma}$ (in 64 gray-scale) so that provides the data determining part 14 with the W color, thereby displaying gray-scale.

However, as shown in FIG. 5b, the W color becomes the minimum datum of the gamma converted RGB data ($R\gamma$, $G\gamma$ and $B\gamma$), thereby displaying gray-scale.

Hereinafter, an arrangement of pixels of an organic electro-luminescent display device so as to embody 4-color display will be described.

FIGS. 8a to 8c are schematic views showing arrangements of pixels of an organic electro-luminescent display device for 4-color display according to another exemplary embodiment of the present invention.

As shown in FIG. 8a, a pixel of conventional display apparatus includes a red subpixel, a green subpixel and a blue subpixel. However, referring to FIG. 8a, a pixel of a display device according to the present invention includes a white subpixel as well

as a red subpixel, a green subpixel and a blue subpixel. The subpixels are arranged in a stripe shape, thereby increasing a luminance of the display apparatus.

Areas of the subpixels may be different from each other. Intervals between switching transistors, data lines or gate lines may also be different from each other. The switching transistors, the data lines and the gate lines correspond to the subpixels. However, intervals between switching transistors, data lines or gate lines may be substantially the same.

As shown in FIG. 8b, a pixel includes a red subpixel, a green subpixel, a blue subpixel and a white subpixel arranged in a 2x2 lattice shape.

As shown in FIG. 8c, a pixel includes two red subpixels R1 and R2, two green subpixels G1 and G2), a blue subpixel and a white subpixel arranged in a 2x3 lattice shape. The two red subpixels may be disposed apart from each other and the two green subpixels may also be disposed apart from each other.

Hereinafter, various exemplary embodiments of an organic electro-luminescent display device that displays 4-color RGBW gray-scale data will be described in detail with reference to the accompanied drawings.

FIG. 9 is a cross-sectional view showing an organic electro-luminescent display device according to another exemplary embodiment of the present invention. Particularly, an organic electro-luminescent display apparatus having an independent light emitting and top light emitting type is described in FIG. 9.

As shown in FIG. 9, an insulating layer 110 is formed on a substrate 105. The substrate 105 is a transparent substrate. The transparent substrate 105 may include a glass substrate, a quartz substrate, a glass ceramic substrate or a crystal glass substrate. Preferably, the substrate is refractory.

Moreover, the insulating layer 110 may have mobile ions or conductivities.

The quartz substrate may not include an insulating layer. The insulating layer 110 may have silicon. Preferably, the silicon insulating layer may include oxygen, nitrogen or a mixture thereof. For example, the silicon insulating layer may include a silicon oxide layer, a silicon nitride layer and a silicon oxynitride layer (SiOxNy, wherein the x and the y is an integer).

A current controlling transistor is formed on the insulating layer 110. The current controlling transistor includes an active layer, a gate insulating layer 120, a gate electrode 125, a first insulating interlayer, a source electrode 130 and a drain electrode 135. The active layer has a source region 312, a channel region 314 and a drain region 116. The gate insulating layer 120 is formed on the active layer, and the gate insulating layer 120 exposes the source region 112 and the drain region 116. The gate electrode 125 is formed on the gate insulating layer 120. The first insulating interlayer 127 is formed on the gate electrode 125 and the gate insulating layer 120, and the first insulating interlayer 127 exposes the source region 112 and the drain region. The source electrode 130 is formed on the first insulating interlayer 127, and the source electrode 130 is connected to the source region. The drain electrode 135 is formed on the first insulating interlayer 127, and is connected to the drain region 135.

The gate electrode 125 may have one layer or a plurality of layers. The source electrode 130 is connected to the source line that extends in a first direction. The drain electrode 135 is connected to the drain line that extends in a second direction different from the first direction. A gate of the current controlling transistor is connected to a drain region of a switching transistor (not shown). The gate electrode 125 of the current controlling transistor is electrically connected to a drain region of the switching transistor through the drain line. A source line is connected to a power supply line (not shown).

A second insulating interlayer 140 is formed on the source electrode 130, the drain electrode 135 and the first insulating interlayer 127. The source electrode 130 is connected to a source line. The drain electrode 135 is connected to a drain line.

A pixel electrode 145 has conductive oxides, and the pixel electrode 145 is connected to the drain electrode 135 of the current controlling transistor through a contact hole. The current controlling transistor is formed under the second insulating interlayer 140. The contact hole opens the second insulating interlayer 140 so as to expose the drain electrode 135 of the current controlling transistor. A partition wall 150 is formed on the pixel electrode 145, and the partition wall 150 defines a luminescent region.

An R organic EL layer 16R, a G organic EL layer 16G, a B organic EL layer 16B and a W organic EL layer 16W are formed on the partition wall 150 and a pixel electrode 145. The contact hole exposes the pixel electrode 145. The R organic EL layer 16R illuminates a red light. The G organic EL layer 16G illuminates a green light, the B organic EL layer 16B illuminates a blue light, and the W organic EL layer 16W illuminates a white light. Each of the R organic EL layer 16R, the G organic EL layer 16G, the B organic EL layer 16B and the W organic EL layer 16W may have one layer or a plurality of layers.

An optical efficiency of an organic EL element having a plurality of layers may be better than an optical efficiency of an organic EL element having one layer. The organic EL layer is formed on the pixel electrode 145 and has a hole injecting layer, a hole transporting layer, a luminescent layer and an electron transporting layer. Preferably, the hole injecting layer is formed on the pixel electrode 145, the hole transporting layer is formed on the hole injecting layer, the luminescent layer is formed on the hole transporting layer, and the electron transporting layer is formed on the

luminescent layer. The organic EL layer may have a hole transporting layer formed on the pixel electrode 145, a luminescent layer formed on the hole transporting layer and an electron transporting layer formed on the luminescent layer. The organic EL layer may also have an electron injecting layer formed on the electron transporting layer.

A metal electrode 170 is formed on the R, G, B and W organic EL layers 16R, 16B, 16B and 16W and protects the R, G, B, W organic EL layers 16R, 16B, 16B and 16W from moisture or contaminants. The metal electrode 170 is a cathode of an organic EL element.

A cathode having magnesium (Mg), lithium (Li) or calcium (Ca) and a protecting electrode may be used instead of using the metal electrode 170. The cathode having the Mg, Li or Ca is formed on the R, G, B, W organic EL layers 16R, 16B, 16B and 16W, and the protecting electrode protects the cathode from moisture or contaminants and connects cathodes to each other. The Mg, Li and Ca have a low work function.

An organic electro-luminescent display device according to another exemplary embodiment of the present invention improves a luminance by means of a 4-color pixel having a white (W) color as well as a red (R) color, a green (G) color and a blue (B) color, thereby improving an optical efficiency. Therefore, power consumption is reduced by the increased optical efficiency.

An organic electro-luminescent display device may be a top luminescent type or a bottom luminescent type. In the bottom luminescent type, a cathode is formed on an organic EL layer so that a light passes through the substrate 105.

FIG. 10 is a cross-sectional view showing an organic electro-luminescent display device according to another exemplary embodiment of the present invention. Particularly, an organic electro-luminescent display apparatus having an independent

light emitting and top light emitting type is described in FIG. 10.

As shown in FIG. 10, an insulating layer 210 is formed on a substrate 205, and a current controlling transistor is formed on the insulating layer 210. The current controlling transistor includes an active layer, a gate insulating layer 220, a gate electrode 225, a first insulating interlayer 227, a source electrode 230 and a drain electrode 235. The active layer has a source region 212, a channel region 214 and a drain region 216. The gate insulating layer 220 is formed on the active layer, and the gate insulating layer 220 exposes the source region 212 and the drain region 216. The gate electrode 225 is formed on the gate insulating layer 220. The first insulating interlayer 227 is formed on the gate electrode 225 and the gate insulating layer 220, and the first insulating interlayer 227 exposes the source region 212 and a drain region 216. The source electrode 230 is formed on the first insulating interlayer 227. The drain electrode 235 is formed on the first insulating interlayer 227, and the drain electrode 235 is connected to the drain region.

A second insulating interlayer 240 is formed on the source electrode 230, the drain electrode 235 and the first insulating interlayer 227. The source electrode 230 is connected to a source line. The drain electrode 235 is connected to a drain line.

A pixel electrode 245 has conductive oxides. The pixel electrode 245 is connected to the drain electrode 235 of the current controlling transistor through a contact hole opening the second insulating interlayer 240. The drain electrode 235 of the current controlling transistor is formed under the second insulating interlayer 240. A partition wall 250 is formed on the pixel electrode 245, and the partition wall 250 defines a luminescent region.

An R organic EL layer 26R, a G organic EL layer 26G, a B organic EL layer 26B and a W organic EL layer 26W are formed on the partition wall 250 and a pixel

electrode 245. The contact hole exposes the pixel electrode 245. The R organic EL layer 26R illuminates a red light, the G organic EL layer 26G illuminates a green light, the B organic EL layer 26B illuminates a blue light, and the W organic EL layer 26W illuminates a white light. Each of the R organic EL layer 26R, the G organic EL layer 26G, the B organic EL layer 26B and the W organic EL layer 26W may have one layer or a plurality of layers.

A transparent electrode 270 is formed on the R, G, B and W organic EL layers 26R, 26B, 26B and 26W and a transparent protecting layer 280 protects the transparent electrode 270 from moisture or contaminants. The transparent electrode 270 is a cathode.

An organic electro-luminescent display device according to another exemplary embodiment of the present invention improves luminance by means of a 4-color pixel having a white (W) color as well as a red (R) color, a green (G) color and a blue (B) color, thereby improving an optical efficiency. Therefore, power consumption is reduced by the increased optical efficiency. The organic electro-luminescent display device may be a top luminescent type or a bottom luminescent type.

Additional processes are needed to manufacture an organic electro-luminescent display device of active light-emitting type. The additional processes include depositing R material, G material, B material and W material and patterning by means of a shadow mask.

Another exemplary embodiment relates to an organic electro-luminescent display device that uses photolithography without the shadow mask process. A display panel of the organic electro-luminescent display device has an improved resolution.

FIG. 11 is a cross-sectional view showing an organic electro-luminescent display device according to another exemplary embodiment of the present invention.

Particularly, the organic electro-luminescent display device having a color filter and a bottom luminescent type is described in FIG. 11.

As shown in FIG. 11, an insulating layer 310 is formed on a substrate 305, and a current controlling transistor is formed on the insulating layer 310. The current controlling transistor includes an active layer, a gate insulating layer 320, a gate electrode 325, a first insulating interlayer 327, a source electrode 330 and a drain electrode 335. The active layer has a source region 312, a channel region 314 and a drain region 316. The gate insulating layer 320 is formed on the active layer, and the gate insulating layer exposes the source region 312 and the drain region 316. The gate electrode 325 is formed on the gate insulating layer 320. The first insulating interlayer 327 is formed on the gate electrode 325 and the gate insulating layer 320, and the first insulating interlayer 327 exposes the source region 312 and the drain region 316. The source electrode 330 formed on the first insulating interlayer 327 is connected to the source region. The drain electrode 335 formed on the first insulating interlayer 327 is connected to the drain region.

A color pixel layer 340 is formed on the source electrode 330, the drain electrode 335 and the first insulating interlayer 327. The source electrode 330 is connected to a source line, and the drain electrode 335 is connected to a drain line. The color pixel layer 340 includes R, G, B and W color filters. Each of the R, G, B and W color filters is formed on a region defined by a current controlling transistor.

A planarizing layer 342 is formed on the color filters. The planarizing layer 342 planarizes the color filters, and the planarizing layer 342 includes an organic layer such as a polyimide layer, a polyamide layer, an acryl layer or benzocyclobutene (BCB) layer. The organic layer may be planarized easily, and the organic layer has a low dielectric constant.

A pixel electrode 345 having conductive oxides is connected to the drain electrode 335 of the current controlling transistor through a contact hole. The planarizing layer 342 and the color pixel layer 340 are formed over the current controlling transistor. The contact hole opens the planarizing layer 342 and the color pixel layer 340 so as to expose the drain electrode 335 of the current controlling transistor. A partition wall 350 formed on the pixel electrode 345 defines R, G, B and W luminescent regions differently from each other.

An EL layer is formed on the partition wall 350 and a pixel electrode 345. The contact hole exposes the pixel electrode 345. Preferably, the EL layer is a W organic EL layer 360.

A metal electrode 370 formed on the W organic EL layer 360 protects the W organic EL layer 360 from moisture or contaminants. The metal electrode 370 is a cathode of an EL element.

A cathode having magnesium (Mg), lithium (Li) or calcium (Ca) and a protecting electrode may be used instead of using the metal electrode 170. The cathode having the Mg, Li or Ca is formed on the W organic EL layers 360. The protecting electrode protects the cathode from moisture or contaminants, and the protecting electrode connects cathodes to each other. The Mg, Li and Ca have a low work function.

An EL element may be formed without a W color filter. However, a second insulating interlayer of the El element without the W color filter is thicker than a second insulating interlayer of an EL element having the W color filter.

An organic electro-luminescent display device according to another exemplary embodiment of the present invention improves luminance by means of forming a white (W) color filter as well as a red (R) color filter, a green (G) color filter and a blue (B)

color filter, thereby improving an optical efficiency. The W, R, G and B color filters are formed between a plane on which a current controlling transistor is formed and an EL layer. Therefore, power consumption is reduced by the increased optical efficiency.

FIG. 12 is a cross-sectional view showing an organic electro-luminescent display device according to another exemplary embodiment of the present invention. The organic electro-luminescent display device is a top luminescent type.

As shown in FIG. 12, an insulating layer 410 is formed on a substrate 405, and a current controlling transistor is formed on the insulating layer 410. The current controlling transistor includes an active layer, a gate insulating layer 420, a gate electrode 425, a first insulating interlayer 427, a source electrode 430 and a drain electrode 435. The active layer has a source region 412, a channel region 414 and a drain region 416. The gate insulating layer 420 formed on the active layer exposes the source region 412 and the drain region 416. The gate electrode 425 is formed on the gate insulating layer 420. The first insulating interlayer 427 is formed on the gate electrode 425 and the gate insulating layer 420, and the first insulating interlayer 427 exposes the source region 412 and the drain region 416. The source electrode 430 is formed on the first insulating interlayer 427, and the source electrode 430 is connected to the source region. The drain electrode 435 formed on the first insulating interlayer 427 is connected to the drain region.

A second insulating interlayer 440 is formed on the first insulating interlayer 427. A contact hole in the second insulating interlayer 440 exposes the source electrode 430 and the drain electrode 435. The source electrode 430 is connected to a source line.

A pixel electrode 445 having conductive oxides is connected to the drain electrode 435 of the current controlling transistor through a contact hole. The current

controlling transistor is formed under the pixel electrode 445. The contact hole opens the second insulating interlayer 440. A partition wall 450 formed on the pixel electrode 445 defines R, G, B and W luminescent regions differently from each other.

An EL layer is formed on the partition wall 450 and a pixel electrode 445. The contact hole exposes the pixel electrode 445. Preferably, the EL layer is a W organic EL layer 360. The W organic EL layer 460 may have one layer or a plurality of layers.

A transparent electrode 470 is formed on the W organic EL layers 460 and a transparent protecting layer 480 protects the transparent electrode 470 from moisture or contaminants. The transparent electrode 470 is a cathode.

A color pixel layer 490 includes R, G, B and W color filters. Each of the R, G, B and W color filters is formed on a region defined by a current controlling transistor.

An organic electro-luminescent display device of top luminescent type according to another exemplary embodiment of the present invention improves luminance by means of a 4-color pixel having a white (W) color as well as a red (R) color, a green (G) color and a blue (B) color, thereby improving an optical efficiency. The W, R, G and B color filters are formed between a plane on which a current controlling transistor is formed and an EL layer. Therefore, power consumption is reduced by the increased optical efficiency.

Moreover, in the organic electro-luminescent display device of top luminescent type, a transparent protecting layer is formed on an EL electrode, and a color filter is formed on the transparent protecting layer, thereby increasing an aperture ratio of the organic electro-luminescent display device. Therefore, the organic electro-luminescent display device of top luminescent type has a higher resolution in comparison with an organic electro-luminescent display device of bottom luminescent type.

Having described the exemplary embodiments of the present invention and its

advantages, it is noted that various changes, substitutions and alterations can be made herein without departing from the spirit and scope of the invention as defined by appended claims.

[EFFECT OF THE INVENTION]

As described above, according to the present invention, each of compensation RGBW gray-scale data may be generated by means of a data driving IC (Integrated Circuit) or a fixed scaling factor. The compensation RGBW gray-scale data are extended. The data driving IC is capable of processing bigger data bit than primary RGB gray-scale data bit. Therefore, luminance and color sensitivity of a primary color may be improved, though a gray-scale level of the compensation RGBW gray-scale data are substantially a gray-scale of a primary color.

In addition, when a compensation RGBW gray-scale data are formed and the gray-scale level of the compensation RGBW gray-scale data are adjacent to a primary color, the gray-scale becomes 1, thereby improving luminance. The compensation RGBW gray-scale data has a W color extracted from a primary RGB gray-scale data.

[CLAIMS]

[CLAIMS 1]

A method for converting a four-color, the method comprising the steps of:

(a) performing a gamma conversion with respect to primary RGB (red, green, and blue) gray-scale data to generate gamma-converted RGB data;

(b) scaling each of the gamma-converted RGB data and then extracting a white color component from the gamma-converted RGB data;

(c) determining four-color RGBW (red, green, blue, and white) data using the gamma-converted RGB data and the white color component; and

(d) performing a reverse-gamma conversion with respect to the four-color RGBW data to generate compensated four-color RGBW data, wherein a scaling factor for scaling becomes 1 to prevent a luminance decreasing when the gray-scale level of the compensation RGBW gray-scale data are adjacent to a primary color.

[CLAIMS 2]

The method of claim 1, wherein step (b) comprises:

(b-1) multiplying the gamma-converted RGB data with the scaling factor and remapping the multiplication results to generate remapped RGB data; and

(b-2) extracting a white color component from the remapped RGB data.

[CLAIMS 3]

The method of claim 2, wherein step (c) comprises:

subtracting the white color component from the remapped RGB gray-scale data to determine new RGB gray-scale data and to determine the white color component as a new white gray-scale data.

[CLAIMS 4]

The method of claim 2, wherein step (b-2) comprises:

when the maximum gray scale level is smaller than or equal to the minimum value of the remapped RGB data, extracting the minimum gray-scale level as the white color components, and

when the maximum gray scale level is greater than the minimum value of the remapped RGB data, extracting the minimum value of the remapped RGB data as the white color components.

[CLAIMS 5]

The method of claim 1, wherein step (b) comprises:

when the minimum value of the gamma converted RGB data is greater than or equal to a first gray-scale value corresponding to a half of a luminance corresponding to the maximum gradation, extracting the first gray-scale value as the white color component, and

when the minimum value of the gamma converted RGB data is smaller than the first gray-scale value, extracting the first gray-scale value as the white color component.

[CLAIMS 6]

The method of claim 1, wherein step (b) comprises:

extracting the minimum value of the gamma converted RGB data as a white color component.

[CLAIMS 7]

An apparatus of converting a four-color, comprising:

a gamma converting part performing gamma conversion with respect to RGB (red, green, and blue) gray-scale data to obtain gamma-converted RGB data;

a remapping part multiplying the gamma-converted RGB data by a scaling factor and remapping the multiplication results to generate remapped RGB data;

a white extracting part extracting a white color component from the remapped

RGB data provided from the remapping part;

a data determining part subtracting the white color component from the remapped RGB data to determine a new RGB gray-scale data and to determine the white color component as a new W gray-scale data; and

a reverse-gamma converting part performing reverse-gamma conversion with respect to the determined four-color RGBW (red, green, blue, and white) data to generate reverse-gamma converted RGBW data, wherein when the gray-scale level of the compensation RGBW gray-scale data are adjacent to a primary color, a scaling factor for scaling becomes 1 to prevent a luminance decreasing.

[CLAIMS 8]

The apparatus for converting a four-color of claim 7, wherein the white extracting part:

generates the minimum gray-scale level of the gamma-converted RGB data as the white color component, when the maximum gray-scale level is smaller than or equal to the minimum value of the remapped RGB data, and

generates the minimum value of the remapped RGB data as the white color component, when the maximum gray-scale level is greater than the minimum value of the remapped RGB data.

[CLAIMS 9]

An apparatus for converting a four-color comprising:

a gamma converting part performing gamma conversion with respect to RGB (red, green, and blue) gray-scale data to obtain gamma-converted RGB data;

a white extracting part extracting a white color component from the gamma-converted RGB data;

a data determining part subtracting the white color component from the

remapped RGB data to determine a new RGB gray-scale data and to determine the white color component as a new W gray-scale data; and

a reverse-gamma converting part performing reverse-gamma conversion with respect to the four-color RGBW data to generate reverse-gamma converted RGBW data, wherein when the gray-scale level of the compensation RGBW gray-scale data are adjacent to a primary color, a scaling factor for scaling becomes 1 to prevent a luminance decreasing.

[CLAIMS 10]

The apparatus for converting a four-color of claim 9, wherein the white extracting part:

generates a first gray-scale value as the white color component, when the minimum value of the gamma converted RGB data is greater than or equal to a first gray-scale value corresponding to a half of luminance corresponding to the maximum gray-scale, and

generates the minimum value as the white color component, when the minimum value of the gamma converted RGB data is smaller than the first gray-scale value.

[CLAIMS 11]

An organic electro-luminescent display device comprising:

an organic electro-luminescent display panel comprising an organic electro-luminescent element emitting light corresponding to a current applied thereto and a driving element controlling a current of the organic electro-luminescent element to control emitting light of the organic electro-luminescent element;

a scan driving part sequentially outputting scan signals;

a data driving part outputting data signals to a data lines of the organic electro-

luminescent display panel; and

a four-color converting part converting primary RGB gray-scale data provided from an external device into compensated RGB gray-scale data and compensated W gray-scale data, the four-color converting part outputting the compensated RGB gray-scale data and the compensated W gray-scale data to the data driving part.

[CLAIMS 12]

The organic electro-luminescent display device of claim 11, wherein the data driving part comprises a data driving integrated circuit (IC) capable of processing bigger data bit than primary RGB gray-scale data bit, and

the data driving IC prevents a luminance decreasing even though the gray-scale level of the compensation RGBW gray-scale data are adjacent to a primary color.

[CLAIMS 13]

The organic electro-luminescent display device of claim 11, wherein the four-color converting part fixes a scaling factor to 1 to prevent a luminance decreasing when the gray-scale level of the compensation RGBW gray-scale data are adjacent to a primary color.

[CLAIMS 14]

The organic electro-luminescent display device of claim 11, wherein the four-color converting part comprises:

a gamma converting part performing gamma conversion with respect to the primary RGB gray-scale data to obtain gamma-converted RGB data;

a remapping part multiplying the gamma-converted RGB data by a scaling factor and remapping the multiplication results to generate remapped RGB data;

a white extracting part extracting a white color component from the remapped RGB data provided from the gamma converting part;

a data determining part subtracting the white color component from the remapped RGB data to determine a new RGB gray-scale data and to determine the white color component as a new W gray-scale data; and

a reverse-gamma converting part performing reverse-gamma conversion with respect to the four-color RGBW data provided from the data determining part to generate reverse-gamma converted RGBW data.

[CLAIMS 15]

The organic electro-luminescent display device of claim 11, wherein the four-color converting part comprises:

a gamma converting part performing gamma conversion with respect to the primary RGB gray-scale data to obtain gamma-converted RGB data;

a white extracting part extracting a white color component from the gamma-converted RGB data provided from the gamma converting part;

a data determining part subtracting the white color component from the remapped RGB data to determine a new RGB gray-scale data and to determine the white color component as a new W gray-scale data; and

a reverse-gamma converting part performing reverse-gamma conversion with respect to the four-color RGBW data provided from the data determining part to generate reverse-gamma converted RGBW data.

[CLAIMS 16]

The organic electro-luminescent display device of claim 11, wherein the organic electro-luminescent display panel comprises:

a substrate;

a plurality of switching element including a source electrode, a drain electrode and a gate electrode, the switching element formed on the substrate;

a plurality of pixel electrode respectively connected to the drain electrode, the pixel electrode defining a first subpixel, a second subpixel, a third subpixel and a four subpixel;

a red subpixel emitting a red light in correspondence with the first subpixel;

a green subpixel emitting a green light in correspondence with the second subpixel;

a blue subpixel emitting a blue light in correspondence with the third subpixel; and

a white subpixel emitting a white light in correspondence with the fourth subpixel.

[CLAIMS 17]

The organic electro-luminescent display device of claim 11, further comprising a metal electrode formed on the pixel electrode,

wherein the red subpixel is defined by a red organic light emitting layer formed between the pixel electrode and the metal electrode to emit a red light, the green subpixel is defined by a green organic light emitting layer formed between the pixel electrode and the metal electrode to emit a green light, the blue subpixel is defined by a blue organic light emitting layer formed between the pixel electrode and the metal electrode to emit a red light, and the white subpixel is defined by a white organic light emitting layer formed between the pixel electrode and the metal electrode to emit a white light.

[CLAIMS 18]

The organic electro-luminescent display device of claim 16, further comprising:

a transparent electrode formed on the pixel electrode; and

a transparent protecting layer formed on the transparent electrode,

wherein the red subpixel is defined by a red organic light emitting layer formed between the pixel electrode and the metal electrode to emit a red light, the green subpixel is defined by a green organic light emitting layer formed between the pixel electrode and the metal electrode to emit a green light, the blue subpixel is defined by a blue organic light emitting layer formed between the pixel electrode and the metal electrode to emit a red light, and the white subpixel is defined by a white organic light emitting layer formed between the pixel electrode and the metal electrode to emit a white light.

[CLAIMS 19]

The organic electro-luminescent display device of claim 16, further comprising:

a white light emitting layer formed on the pixel electrode; and

a metal electrode formed on the white light emitting layer,

wherein the red subpixel is defined by a red color filter layer formed between the switching element and the pixel electrode to only transmit red components of lights by the white light emitting layer, the green subpixel is defined by a green color filter layer formed between the switching element and the pixel electrode to only transmit green components of lights by the white light emitting layer, the blue subpixel is defined by a blue color filter layer formed between the switching element and the pixel electrode to only transmit blue components of lights by the white light emitting layer, and the white subpixel is defined by a white color filter layer formed between the switching element and the pixel electrode to only transmit white color components of lights by the white light emitting layer.

[CLAIMS 20]

The organic electro-luminescent display device of claim 16, further comprising:

a white light emitting layer formed on the pixel electrode;

a transparent electrode formed on the white light emitting layer; and

a transparent protecting layer formed on the transparent electrode,

wherein the red subpixel is defined by a red color filter layer formed on the transparent protecting layer to only transmit red components of lights by the white light emitting layer, the green subpixel is defined by a green color filter layer formed on the transparent protecting layer to only transmit green components of lights by the white light emitting layer, the blue subpixel is defined by a blue color filter layer formed on the transparent protecting layer to only transmit blue components of lights by the white light emitting layer, and the white subpixel is defined by a white color filter layer formed on the transparent protecting layer to only transmit white color components of lights by the white light emitting layer.

[CLAIMS 21]

The organic electro-luminescent display device of claim 16, further comprising:

a white light emitting layer formed on the pixel electrode;

an organic light emitting layer formed on the white light emitting layer; and

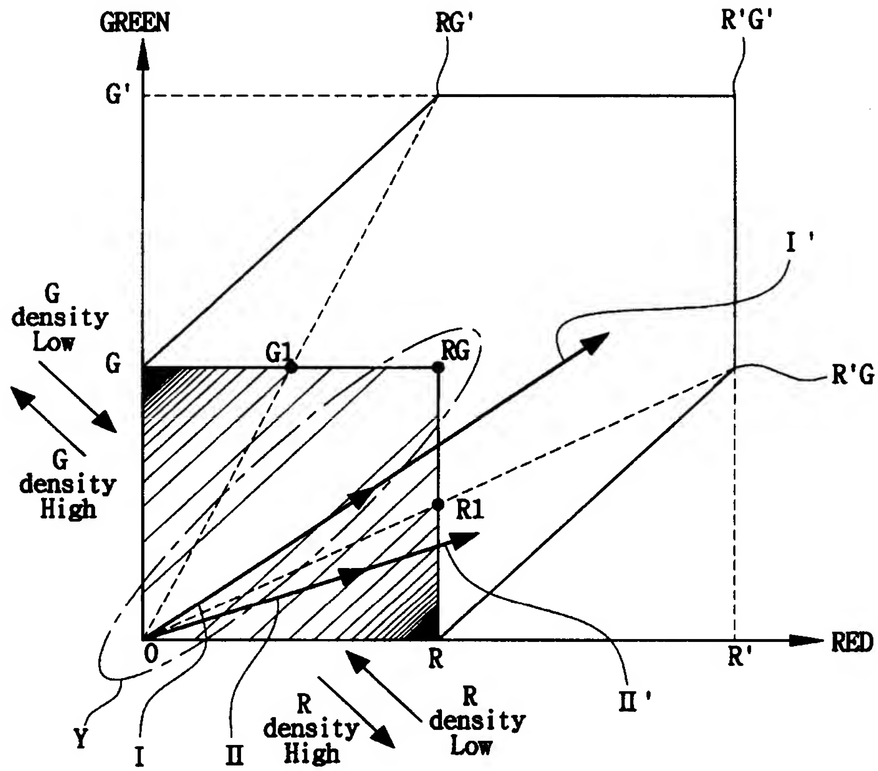
a transparent protecting layer formed on the organic light emitting layer,

wherein the red subpixel is defined by a red color filter layer formed on the transparent protecting layer to only transmit red components of lights by the white light emitting layer, the green subpixel is defined by a green color filter layer formed on the transparent protecting layer to only transmit green components of lights by the white light emitting layer, the blue subpixel is defined by a blue color filter layer formed on

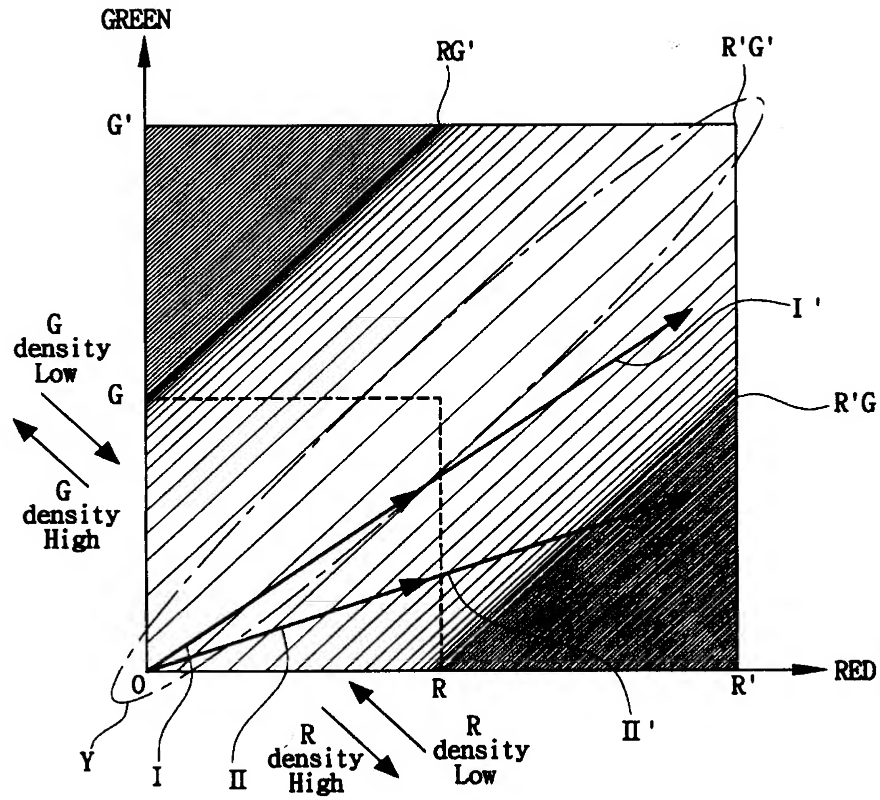
the transparent protecting layer to only transmit blue components of lights by the white light emitting layer, and the white subpixel is defined by an area transmitting lights by the white light emitting layer on the transparent protecting layer.

[DRAWING]

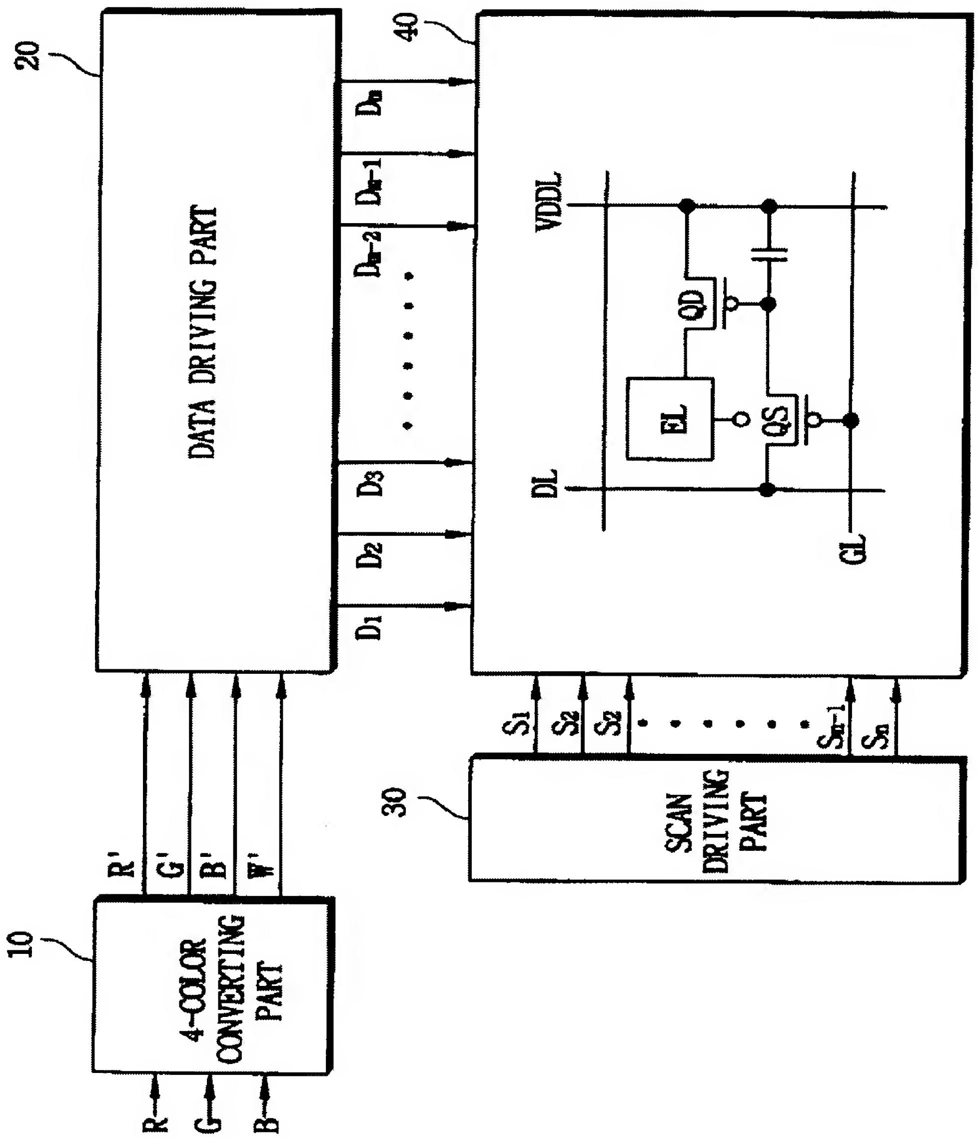
[FIG. 1]



[FIG. 2]

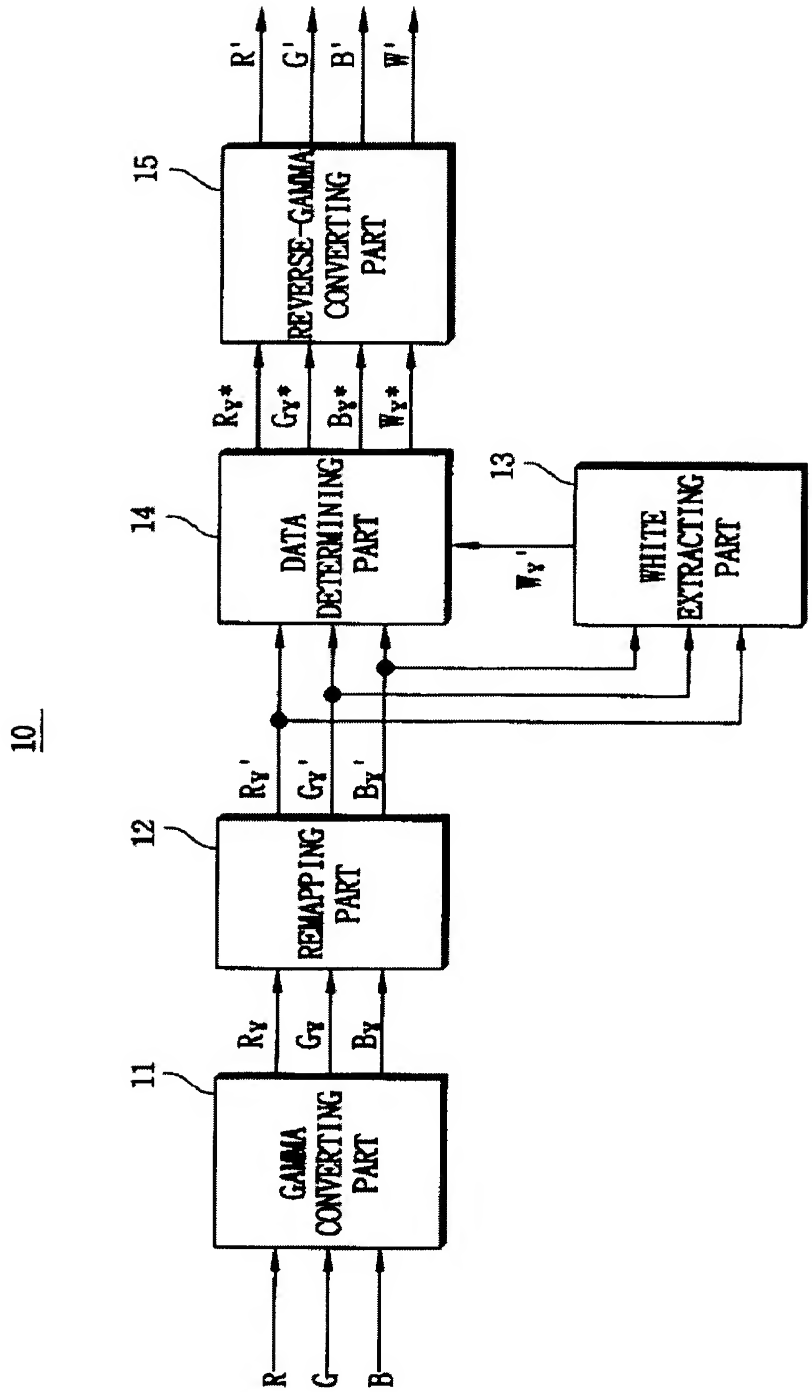

GREEN
RG'
R'G'
G'
I '
G
density
Low
G
R'G
G
density
High
0
R
R'
RED
II '
R
density
High
R
density
Low
Y
I
II

[FIG. 3]

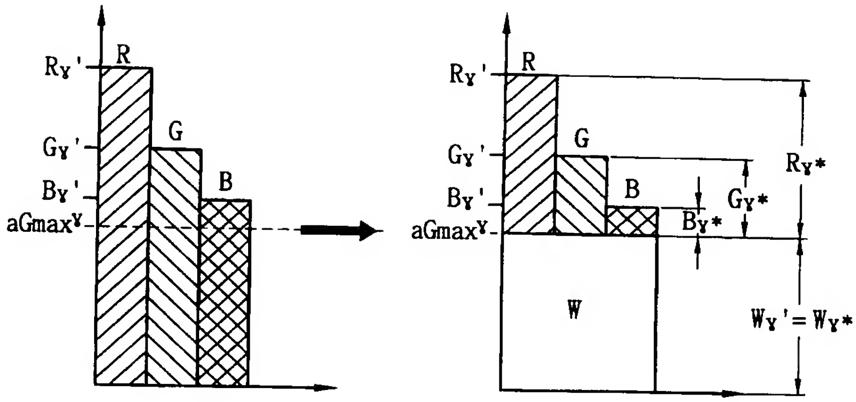


10
4-COLOR CONVERTING PART
R
G
B
R'
G'
B'
W'
20
DATA DRIVING PART
30
SCAN DRIVING PART
40
VDDL
DL
GL
EL
QD
QS

[FIG. 4]

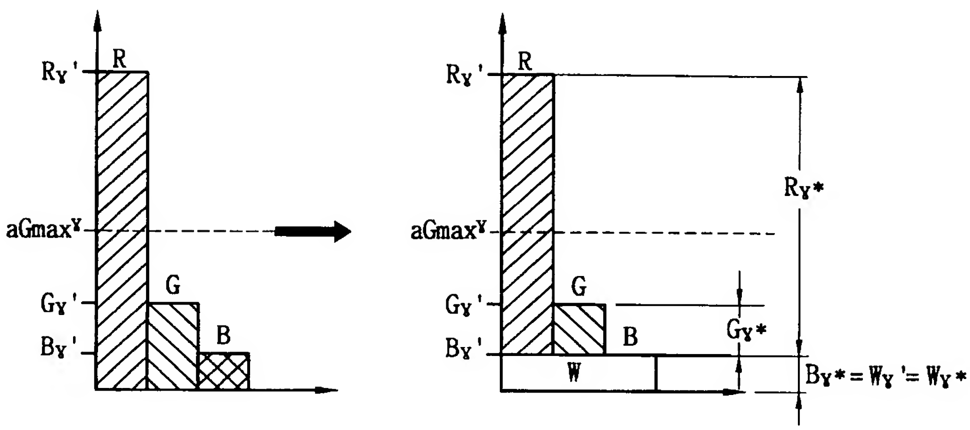

10
R
G
B
11
GAMMA CONVERTING PART
R_Y
G_Y
B_Y
12
REMAPPING PART
R_Y'
G_Y'
B_Y'
13
WHITE EXTRACTING PART
W_Y'
14
DATA DETERMINING PART
R_Y*
G_Y*
B_Y*
W_Y*
15
REVERSE-GAMMA CONVERTING PART
R'
G'
B'
W'

[FIG. 5a]



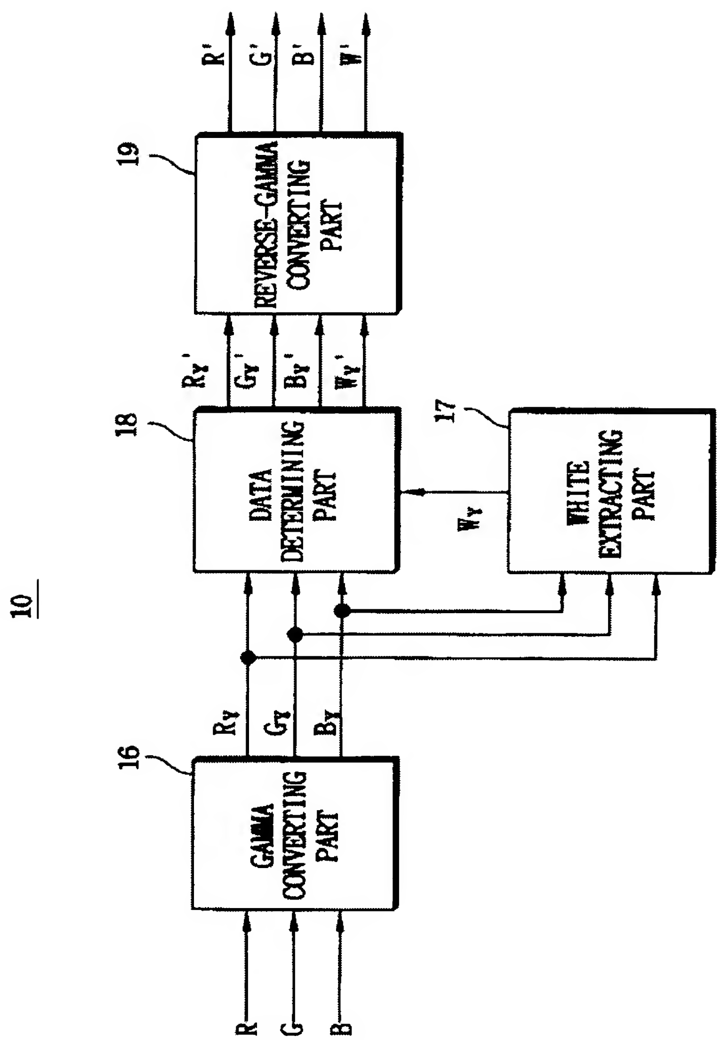
R_Y'
R
G_Y'
G
B_Y'
B
$aGmax^Y$
R_Y'
R
G_Y'
G
B_Y'
B
$aGmax^Y$
R_Y*
G_Y*
B_Y*
W
$W_Y' = W_Y*$

[FIG. 5b]



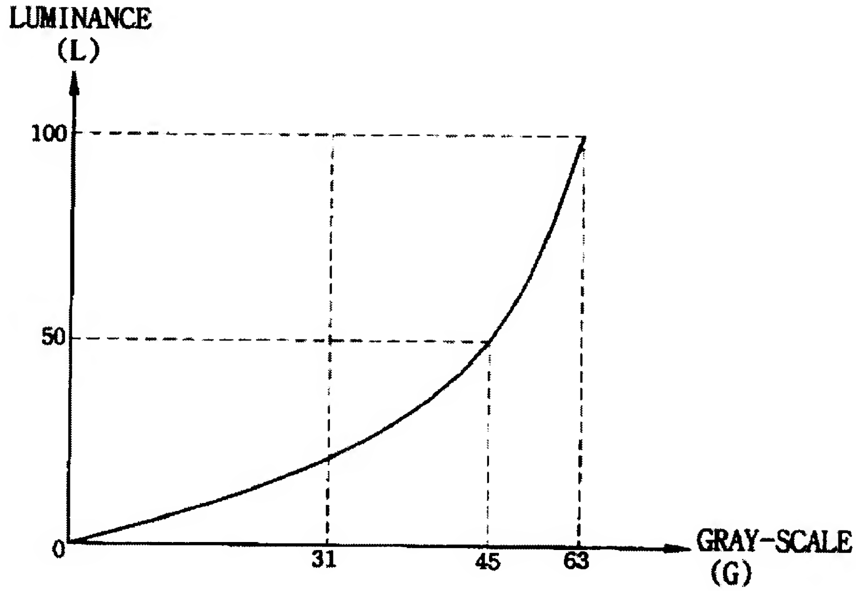
R_Y'
R
$aGmax^Y$
G_Y'
G
B_Y'
B
R_Y'
R
R_Y*
$aGmax^Y$
G_Y'
G
B_Y'
B
G_Y*
W
$B_Y* = W_Y' = W_Y*$

[FIG. 6]

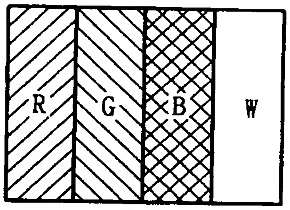


10
GAMMA CONVERTING PART
16
DATA DETERMINING PART
18
WHITE EXTRACTING PART
17
REVERSE-GAMMA CONVERTING PART
19
R
G
B
Rγ
Gγ
Bγ
Wγ
Rγ'
Gγ'
Bγ'
Wγ'
R'
G'
B'
W'

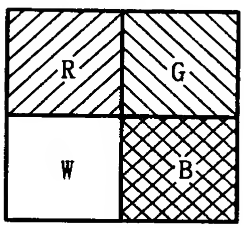
[FIG. 7]



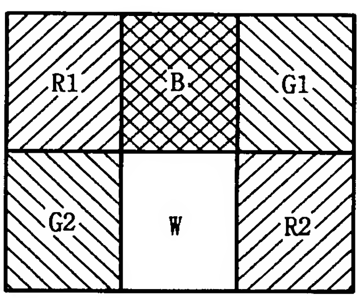
[FIG. 8a]



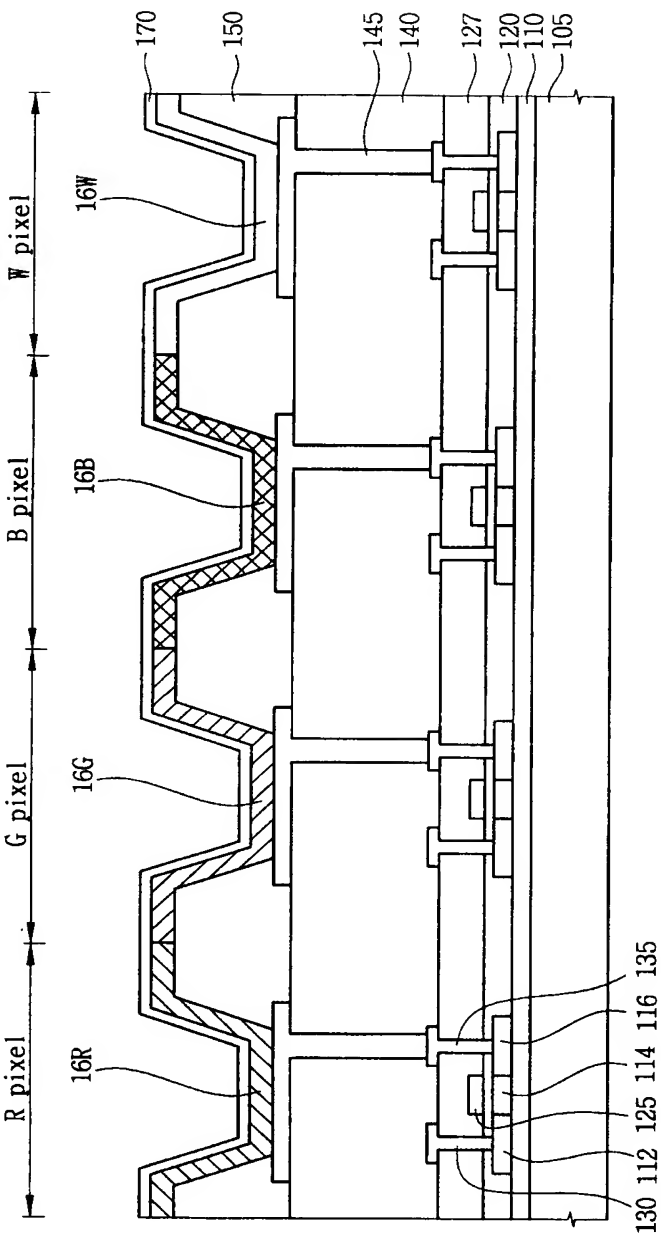
[FIG. 8b]



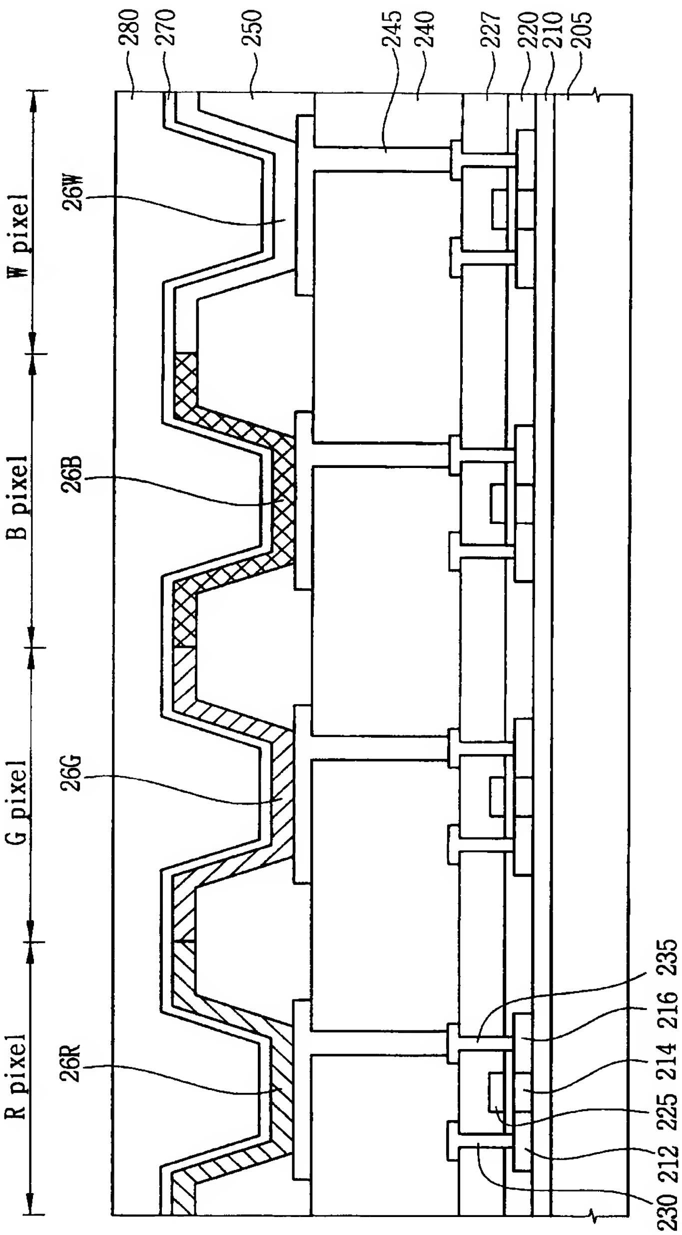
[FIG. 8c]



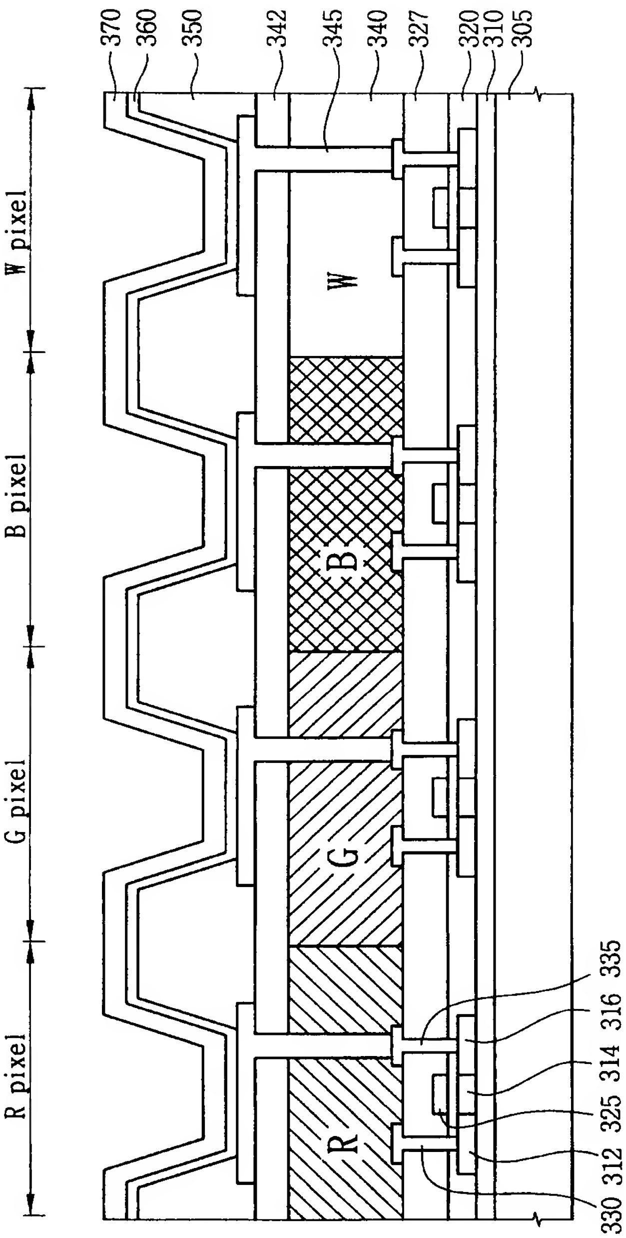
[FIG. 9]


170
150
145
140
127
120
110
105
W pixel
B pixel
G pixel
R pixel
16W
16B
16G
16R
130
112
125
114
116
135

[FIG. 10]

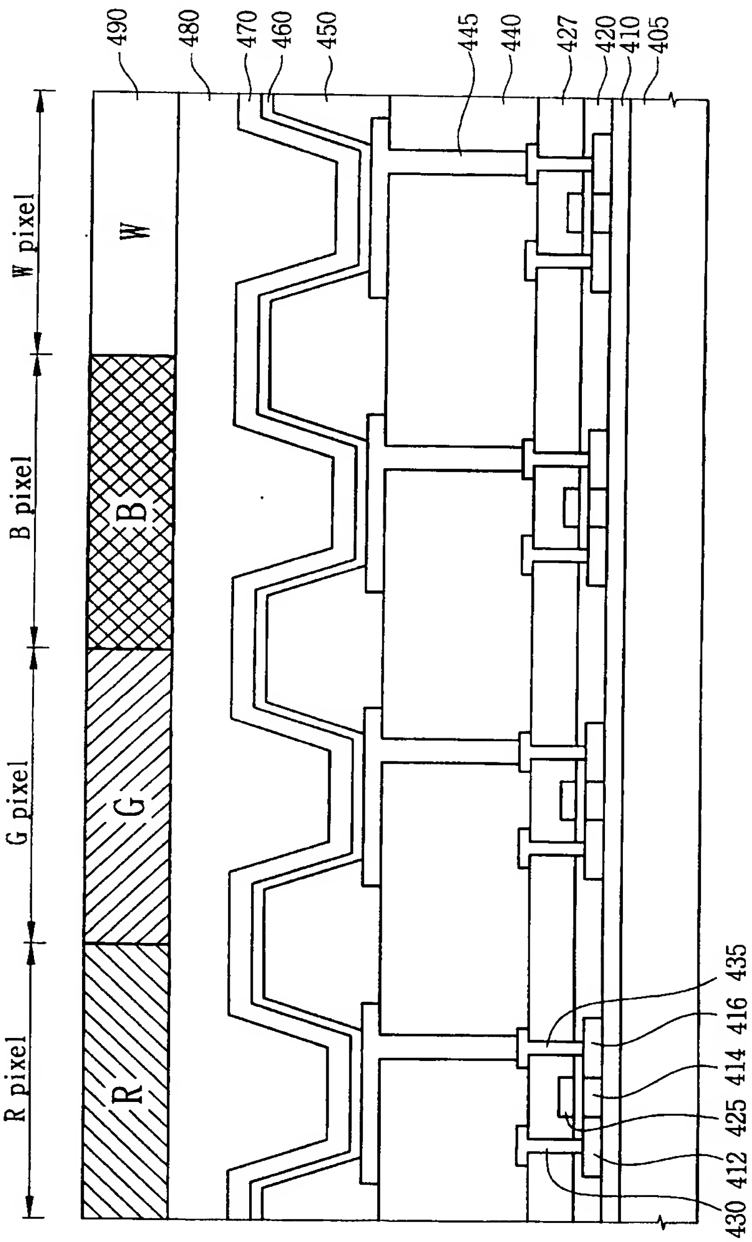

280
270
250
245
240
227
220
210
205
W pixel
B pixel
G pixel
R pixel
26W
26B
26G
26R
235
216
214
225
212
230

[FIG. 11]



370
360
350
342
345
340
327
320
310
305
W pixel
B pixel
G pixel
R pixel
W
B
G
R
335
316
314
325
312
330

[FIG. 12]


W pixel
B pixel
G pixel
R pixel
W
B
G
R
490
480
470
460
450
445
440
427
420
410
405
435
416
414
425
412
430